5G NR network deployment is now – let's test!

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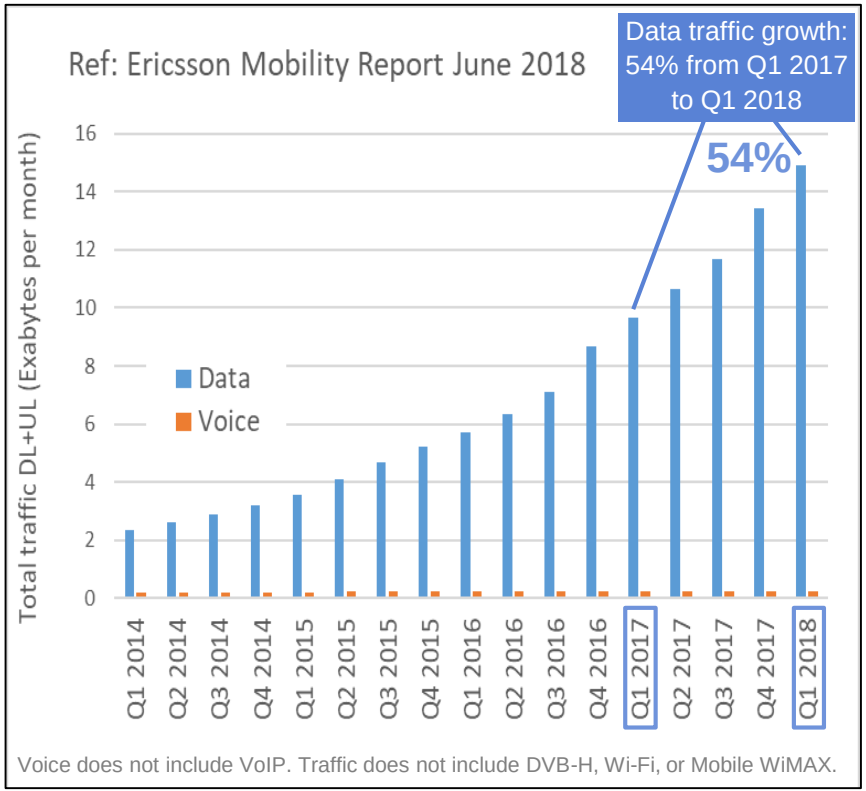
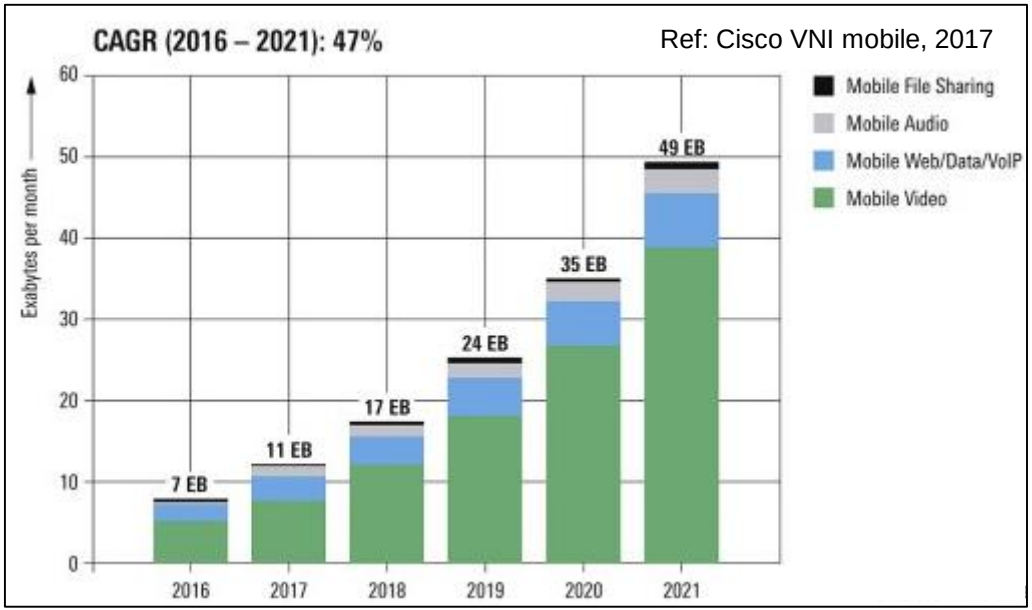
Mobile Data Traffic Growth: it is happening!

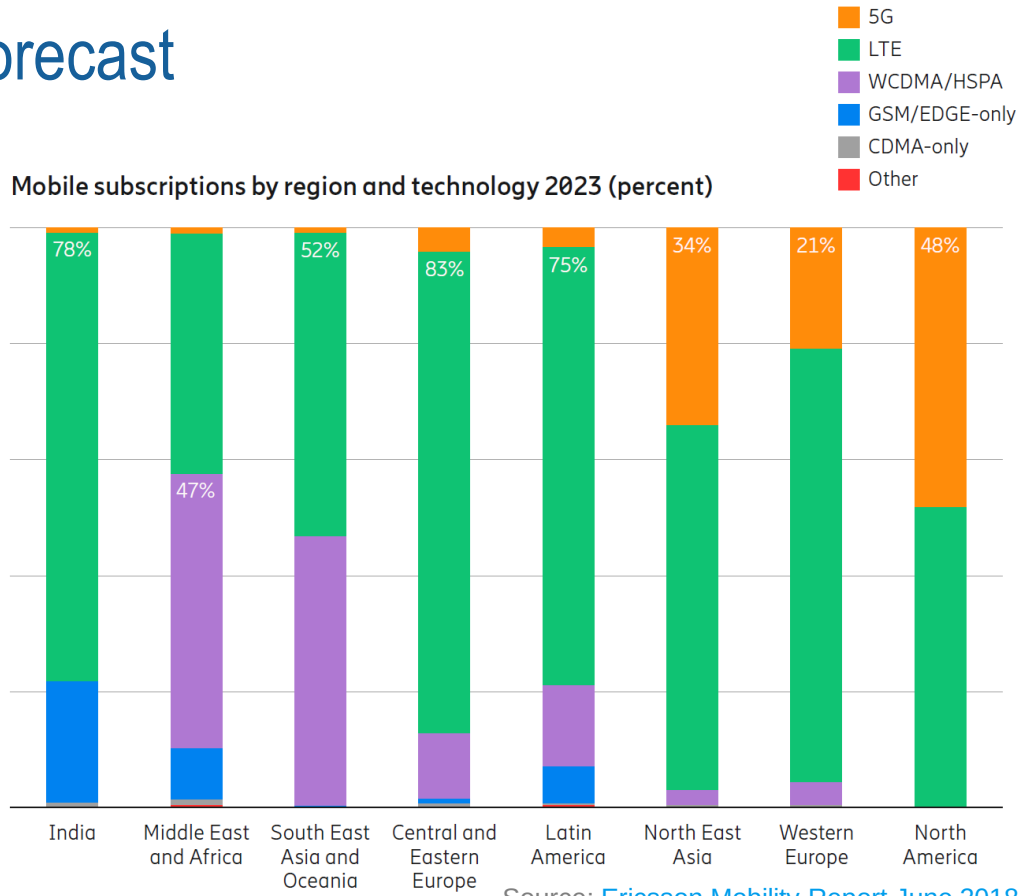




- **Absolute amount of data: 3-fold inc. in 3 yrs!**
- **Operators have to invest for higher capacity**

4G today and 5G technology forecast

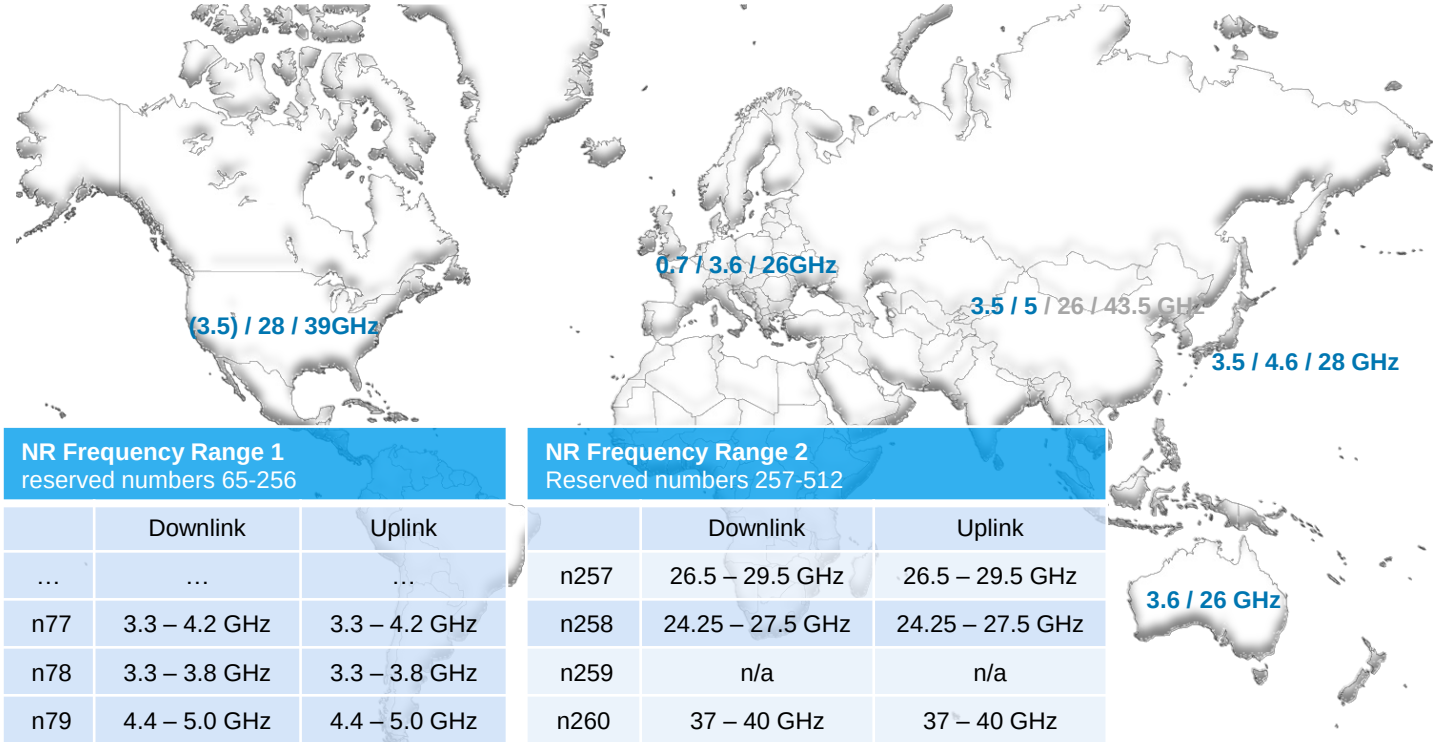
- **GSA Reports (August ‘18):**
  - **681** commercially launched LTE or LTE-Advanced networks in **208** countries. **39** cat. 18 devices (4 networks supporting cat. 18 speeds)
  - **67** telecom operators in **39** countries have announced intentions of making **5G** available to their customers between 2018 and 2022



Source: GSA Evolution from LTE to 5G report, August 2018
https://gsacom.com/paper/5g-evolution-lte-global-market-status/

Source: Ericsson Mobility Report June 2018

Frequency trends for 5G



NR Frequency Range 1
reserved numbers 65-256

	Downlink	Uplink
…	…	…
n77	3.3 – 4.2 GHz	3.3 – 4.2 GHz
n78	3.3 – 3.8 GHz	3.3 – 3.8 GHz
n79	4.4 – 5.0 GHz	4.4 – 5.0 GHz
…	…	…

NR Frequency Range 2
Reserved numbers 257-512

	Downlink	Uplink
n257	26.5 – 29.5 GHz	26.5 – 29.5 GHz
n258	24.25 – 27.5 GHz	24.25 – 27.5 GHz
n259	n/a	n/a
n260	37 – 40 GHz	37 – 40 GHz

Europe
- 700 MHz
- 3.4 - 3.8 GHz
- 24.25 - 27.5 GHz

China
- 3.3 - 3.6 GHz
- 4.8 - 5.0 GHz
- 24.75 - 27.5GHz (study)
- 37 - 43.5 GHz (study)

US
- [CBRS band (3.5GHz)]
- 27.5 - 28.35 GHz
- 37.0 - 40 GHz
- 64 - 71 GHz (unlicensed)

Australia
- 3.6 GHz
- 26 GHz

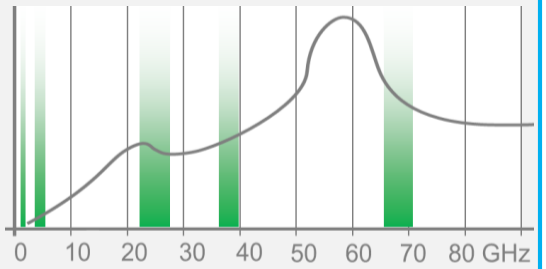
Korea
- 3.5 GHz
- 28 GHz

Japan
- 4.4 - 4.9 GHz
- 28 GHz

Key challenges related to 5G NR RAN

New spectrum

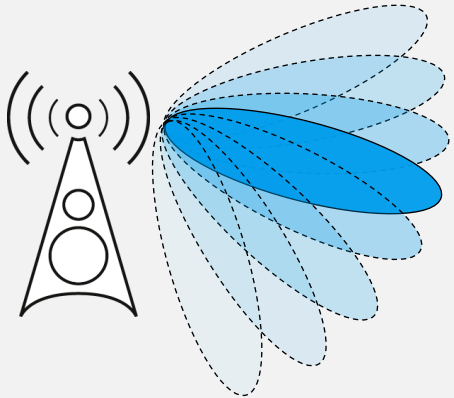
- Even 3.5 GHz is different from today's frequencies



- What about coverage?
- Spectrum clearance?

Beamforming for Synch. and Broadcast Signals

- How does beamforming work?



Flexibility of air interface and gNB configuration

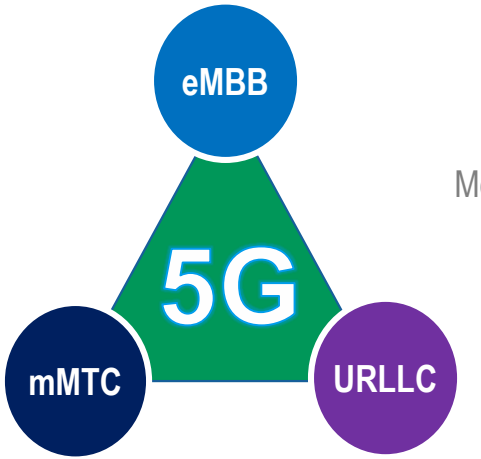
- Bandwidth:
  5, 10, 15, 20, 25, 30, 40, 50, 60, 80, 100 MHz (FR1)
  50, 100, 200, 400 MHz (FR2)
- Subcarrier Spacing:
  15, 30, 60 kHz (FR1)
  60, 120, (240) kHz (FR2)
- Mapping onto antenna ports: single beam / multi beam sweeping

➢ **New technology elements drive the need for (and complexity of) 5G NR network measurements**

5G Use Cases drive the need to test

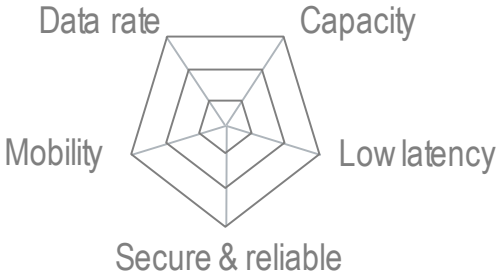
5G Use Cases → Required Network Characteristics → **RAN operation & performance** → Field Test

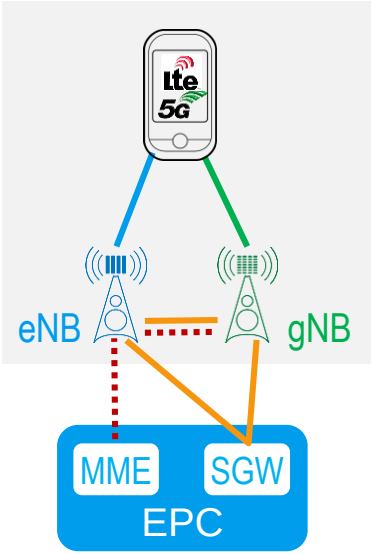
enhanced Mobile Broadband

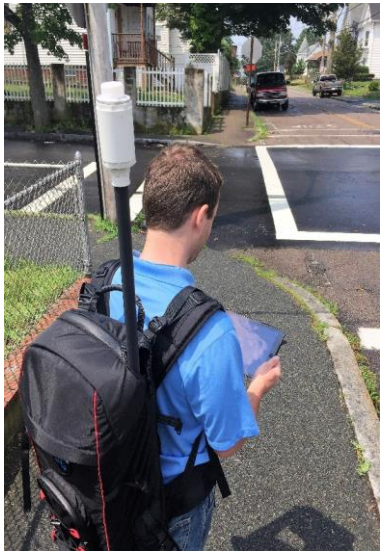


Massive Machine Type Communication

Ultra reliable & low latency communication







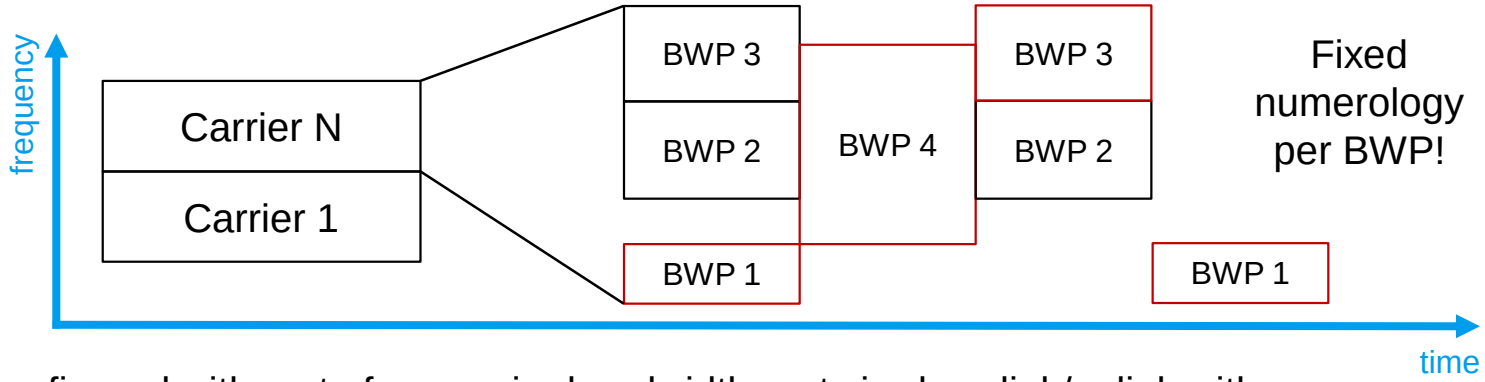
Contents

- Market drivers and key challenges of 5G NR networks
- **5G NR technology**
- 5G NR field measurements
- Main take-aways and conclusion

“Demystifying the 5G NR physical layer”

Bandwidth Parts (BWP)

- BWP: Contiguous subset of physical resource blocks on a given carrier for a given numerology

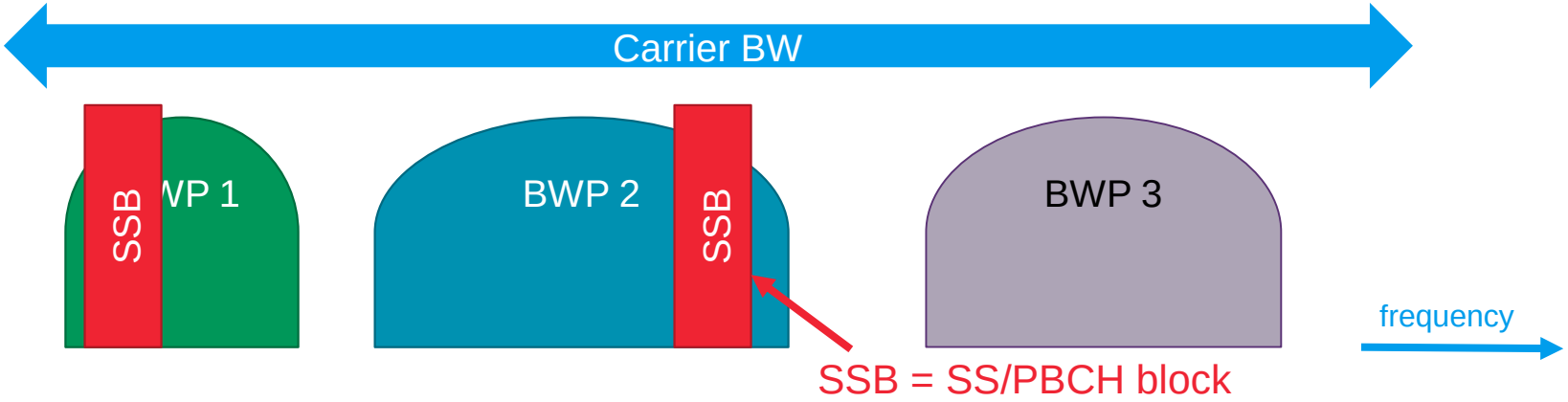


- A UE can be configured with up to four carrier bandwidth parts in downlink/uplink with a single downlink/uplink carrier bandwidth part being active at a given time.
- UE is not expected to receive outside an active DL BWP
- UE shall not transmit outside an active UL BWP
- Active BWP can be switched by DCI

DCI: DL Control Information

How can a UE identify a 5G carrier?

First action of UE looking for 5G cell: search for Synchronization Signals

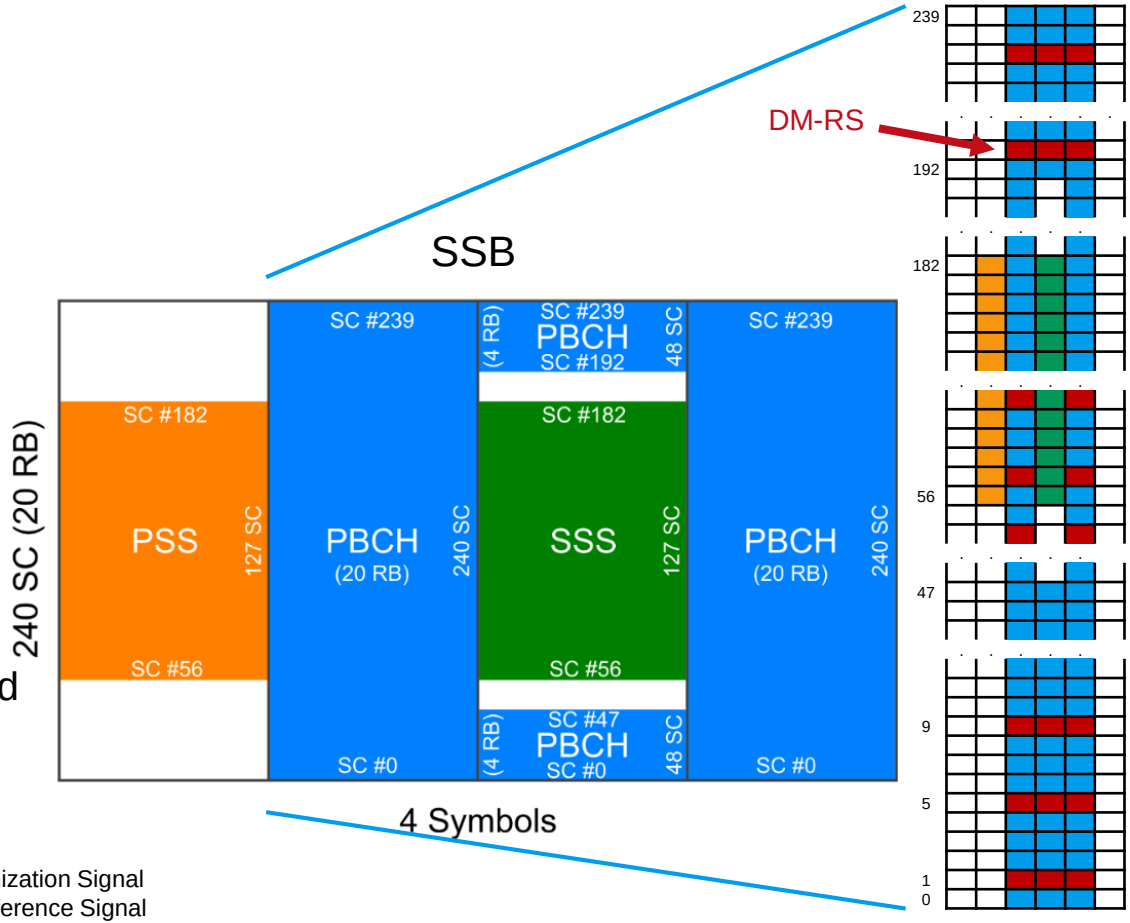


- One SSB is always transmitted → the **only Always-On signal** in 5G NR!
- The 5G NR UE uses the SSB for
  - Synchronization
  - System information (MIB/SIB)
  - Cell and Beam quality measurements

SSB (or SS/PBCH Block)

- Time domain:
  SS/PBCH block consists of 4 OFDM symbols, where PSS, SSS and PBCH with associated DM-RS occupy different symbols
- Frequency domain:
  SS/PBCH block consists of 240 contiguous subcarriers

- Like in LTE, the PCI can be determined from the used PSS/SSS sequences



PSS: Primary Synchronization Signal
PBCH: Physical Broadcast Channel
SSS: Secondary Synchronization Signal
DM-RS: DeModulation Reference Signal

SS/PBCH Blocks

Occurrence in the frame: Case A, B and C

Case A (15kHz)

f ≤ 3GHz (L=4)

3 < f ≤ 6GHz (L=8)

Case B (30kHz)

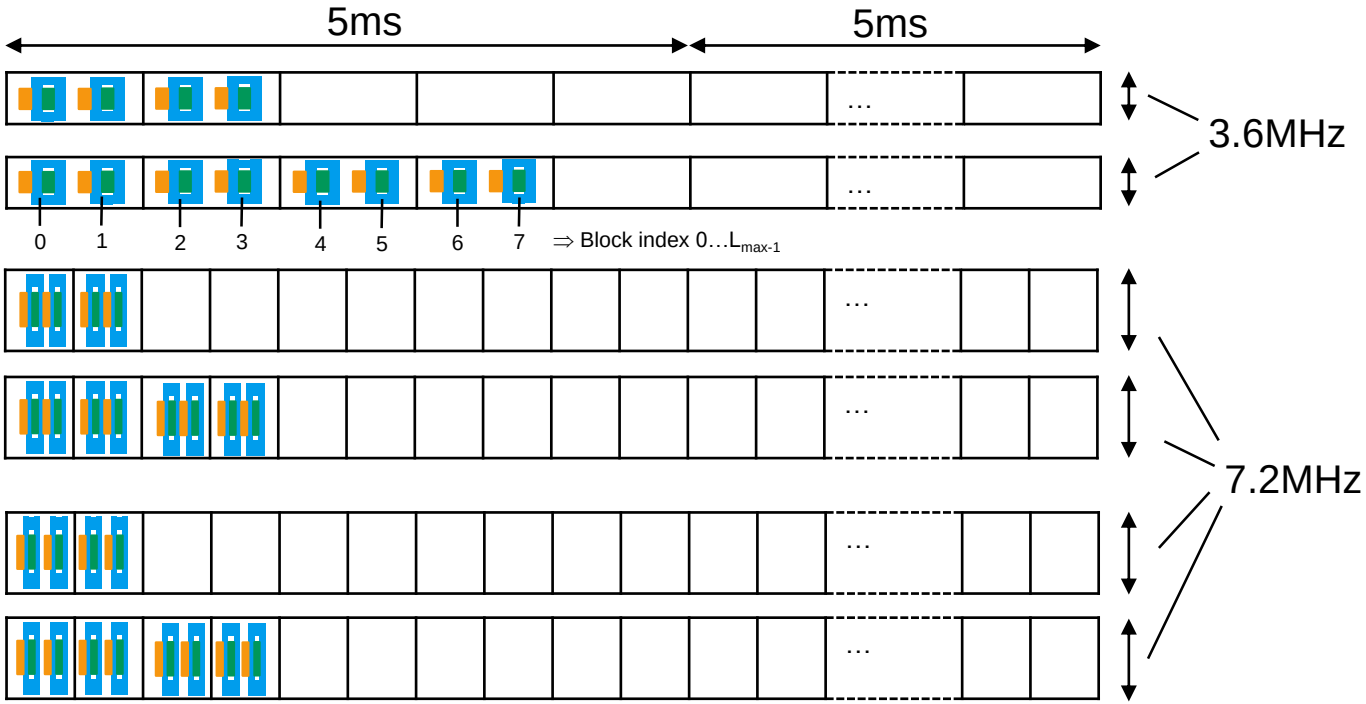
f ≤ 3GHz (L=4)

3 < f ≤ 6GHz (L=8)

Case C (30kHz)

f ≤ 3GHz (L=4)

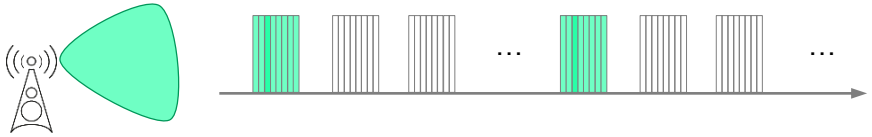
3 < f ≤ 6GHz (L=8)



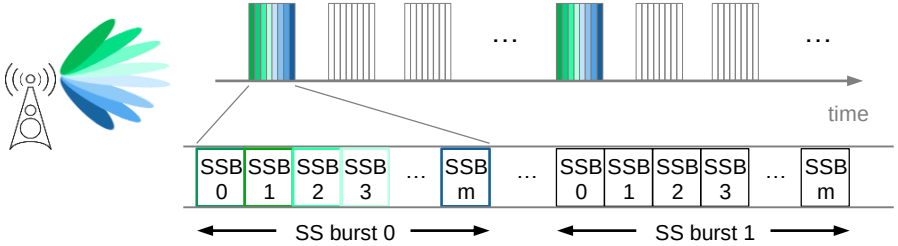
SSB – in single beam or multi beam configuration

- SSB index is used to separate SSB transmission on different beams (encoded in the MIB)
- Mapping of antenna ports and physical beams to the SSB index can differ between infrastructure suppliers
- SS Bursts can also be repeated (periodicity is given in MIB)

Single Beam



Multi Beam sweeping



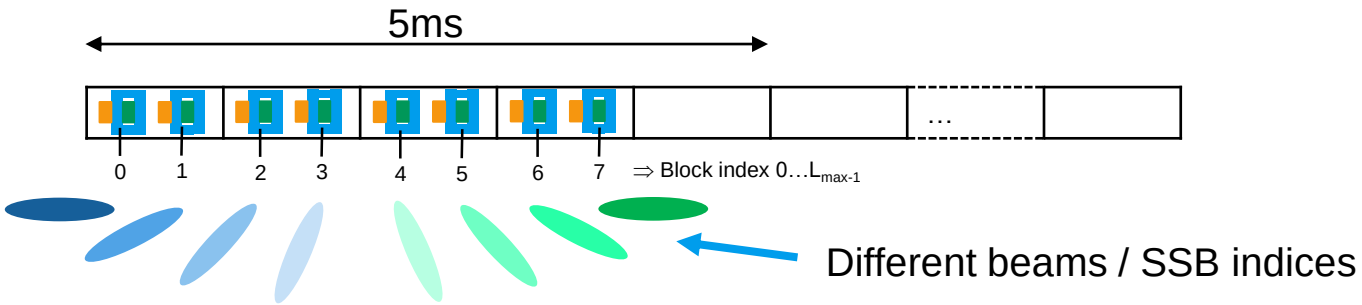
➢ **5G NR network measurements need to cope with high flexibility and configurability**

SSB and different beams – „beamforming“

- Demodulation of the PBCH → determines the SSB **index** and
  → distinguishes between the periodically broadcasted SSBs
- Each SSB uses different DM-RS embedded in the PBCH
- Example: Case A with subcarrier spacing of 15 kHz and 8 SSB indices

Case A (15kHz)

3 < f ≤ 6GHz (L=8)



➢ **Beamforming of synchronization signals and broadcast information via 5G NR SSBs**

Contents

Field Deployments

Preparation: NSA (Non-Standalone) mode network measurements

- How easy is the multi-technology scanner configuration (5G NR and LTE)?

Test 1: RF measurements per SSB index

- Average
- Over time
- Real-time

Test 2: SSB / beam ranking

- History of best beams over time
- Best beam index over geography

Test 3: Coverage visualization

- RSRP in statistical evaluation
- Coverage over geography

Test 1 – scanner configuration

➢ **Multi-technology scanner configuration (5G NR and LTE)**

Test1: RF measurements per SSB index

- Average
- Over time
- Real-time

Test 2: SSB / beam ranking

- History of best beams over time
- Best beam index over geography

Test 3: Coverage visualization

- RSRP in statistical evaluation
- Coverage over geography

Test 2– RF measurements

- **5G NR RF data collection, analysis and visualization performed in prepared and self-configurable views**

Test 1: RF measurements per SSB index	Test 2: SSB / beam ranking	Test 3: Coverage visualization
▮ Average ▮ Over time ▮ Real-time	▮ History of best beams over time ▮ Best beam index over geography	▮ RSRP in statistical evaluation ▮ Coverage over geography

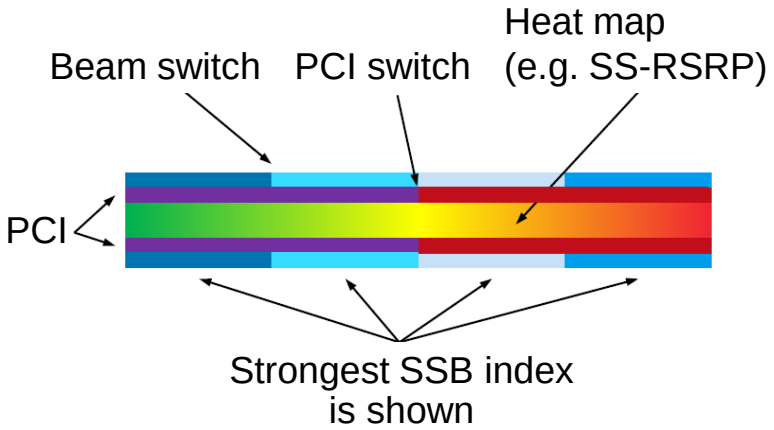
Test 2: Can we map the SSB indices on beams? How does beamforming work?

- First approach:

  Assumption: Each SSB index can be mapped to a certain beam

- How to analyze that?

  Use map feature and display the strongest SSB index on a map

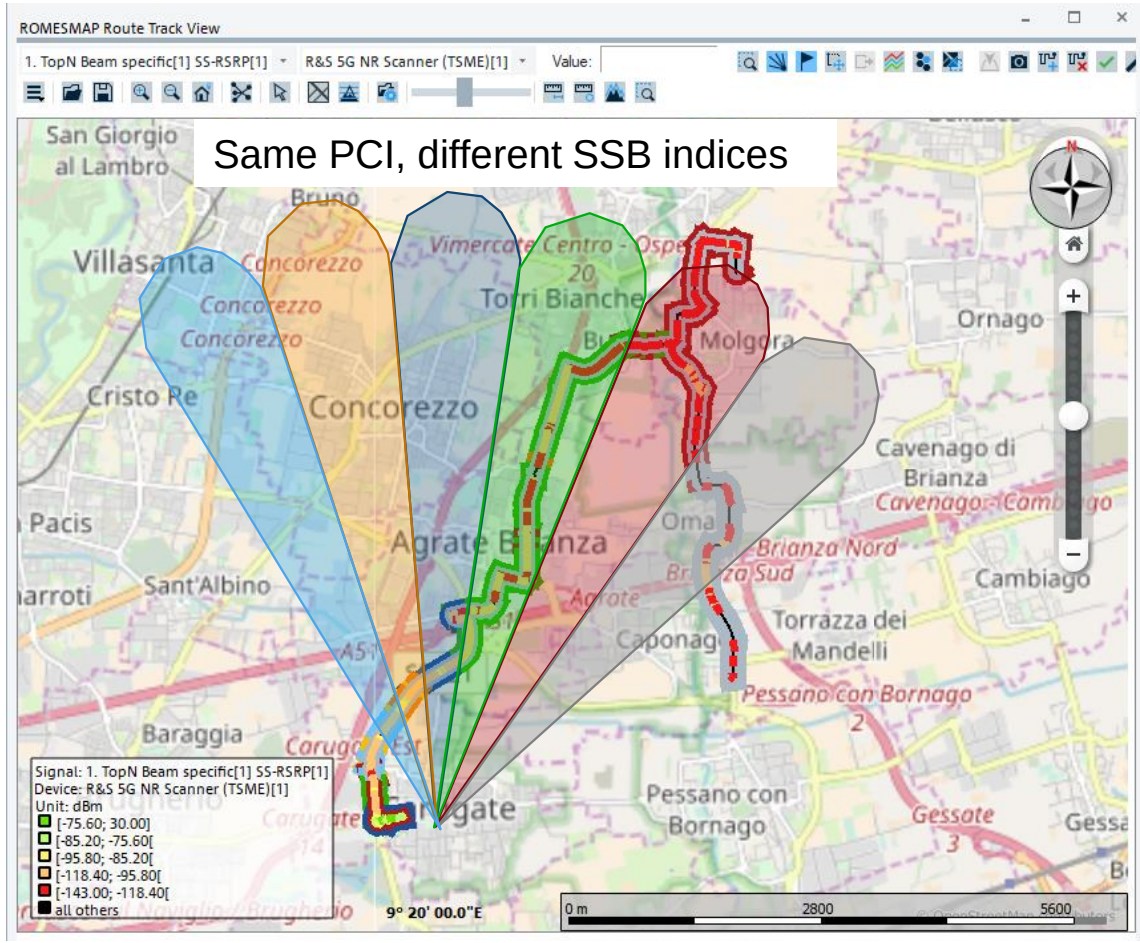


Main take-away – SSB / beam ranking

- **SSB / beam index visualized over time (history) and on the map** ✓

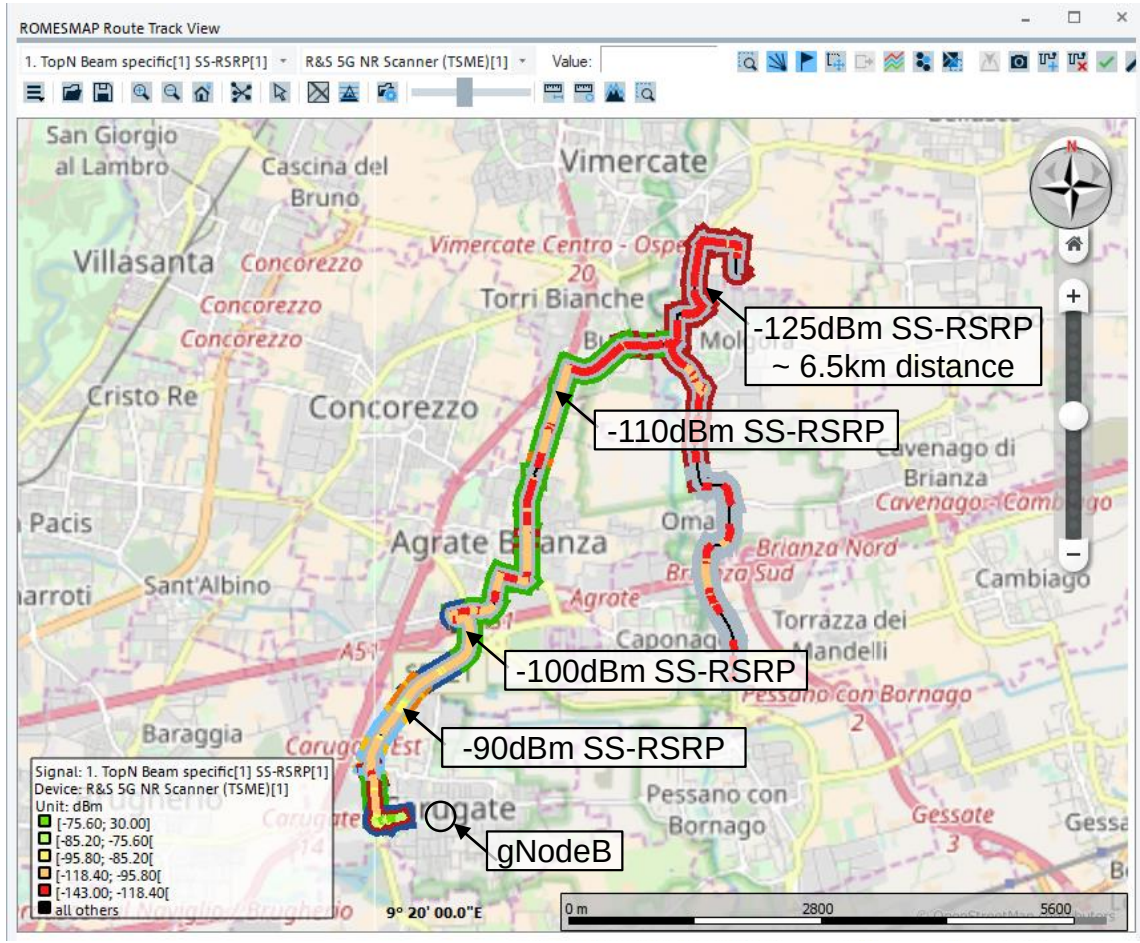
Test 3:
Coverage visualization

- RSRP in statistical evaluation
- Coverage over geography

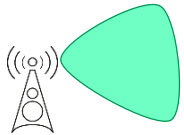


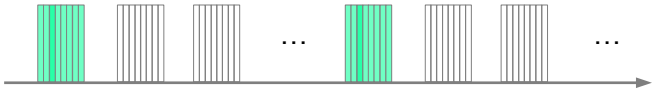
Main take-away – Coverage

- **Expected UE sensitivity: ~ -120 dBm (SS-RSRP)**
- **Surprisingly good SSB coverage in suburban area**
- **Analog SSB beamforming allows for long radio range**



gNB configuration options:
Single Beam Example





5G NR Scanner TopN View:1 | R&S 5G NR Scanner (TSME)[1]

Top N: SSB RSRP | Auto Width

Top N List

Color	#	TopX	PCI	SSB Idx	Power	SS-RS...	SS-SI...	SS-RS...	GSCN	SS-Ref
	1	1	20	0	-63.1	-66.1	-0.1	-13.3	---	3500....

Top N Chart (Click to open)

5G NR Scanner Chart View:1 | R&S 5G NR Scanner (TSME)[1]

PCI Filter: [Beam@]PCI;[Beam@]PCI;... | @ 3.500000 GHz | Clear

SS-RSRP [dBm]

-64.5 -65.0 -65.5 -66.0 -66.5 -67.0 -67.5 -68.0 -68.5 -69.0

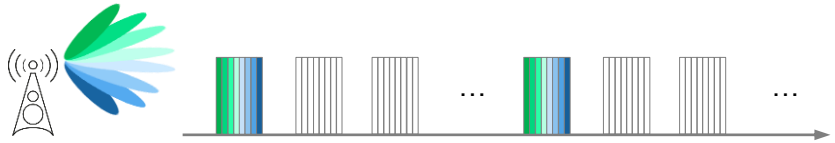
0.0 -0.1 -0.1 -0.2 -0.2 -0.3 -0.3

5G NR Scanner Chart View Properties

	0@20	--/--	--/--	--/--	--/--	--/--	--/--	--/--
SS-RSRP [dBm]	-66.1							
SS-SINR [dB]	-0.1							
SS-RSRQ [dB]	-13.3							

One PCI and SSB index detected

gNB configuration options:
Multi Beam Example



5G NR Scanner TopN View:1 | R&S 5G NR Scanner (TSME)[1]

Top N: SSB RSRP | Auto Width

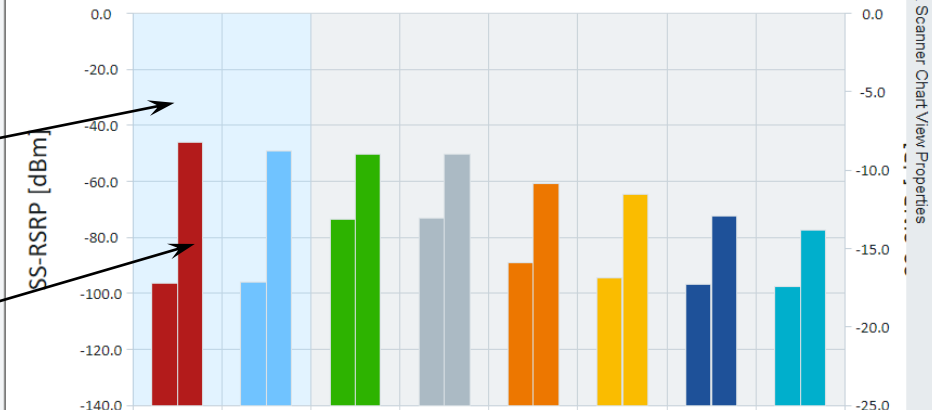
Top N List

Color	#	TopX	PCI	SSB Idx	Power	SS-RSRP	SS-SINR	SS-RS...	GSCN	SS-Ref
	1	1	15	0	-65.3	-75.0	-9.1	-19.9	---	3749.80
	2	2	15	2	-67.1	-76.6	-9.0	-19.9	---	3749.80
	3	3	15	3	-77.7	-89.0	-10.9	-21.5	---	3749.80
	4	4	13	7	-87.7	-96.5	-8.2	-19.2	---	3749.80
	5	5	15	1	-83.6	-96.8	-12.9	-23.5	---	3749.80
	6	6	15	4	-82.6	-94.4	-11.6	-22.2	---	3749.80
	7	7	13	6	-86.5	-95.9	-8.8	-19.6	---	3749.80
	8	8	15	5	-83.4	-97.4	-13.8	-24.3	---	3749.80

Top N Chart (Click to open)

5G NR Scanner Chart View:1 | R&S 5G NR Scanner (TSME)[1]

PCI Filter: [Beam@]PCI;[Beam@]PCI;... @ Any Frequency | Clear



	7@13	6@13	2@15	0@15	3@15	4@15	1@15	5@15
SS-RSRP [dBm]	-96.5	-95.9	-73.4	-73.0	-89.0	-94.4	-96.8	-97.4
SS-SINR [dB]	-8.2	-8.8	-9.0	-9.0	-10.9	-11.6	-12.9	-13.8
SS-RSRQ [dB]	-19.17	-19.61	-19.8	-19.87	-21.5	-22.23	-23.47	-24.3

5G NR Scanner Chart View Properties

Cell Color by PCI

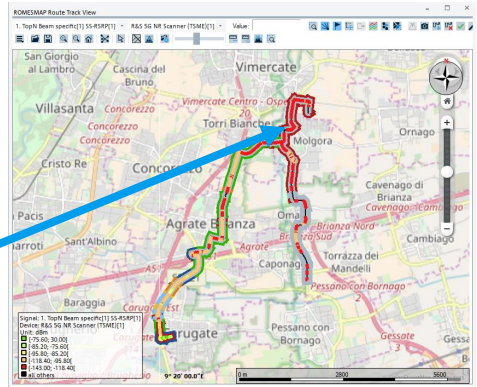
Beam Color by SSB Index

Contents

Main take-aways from first drive tests in 5G NR networks

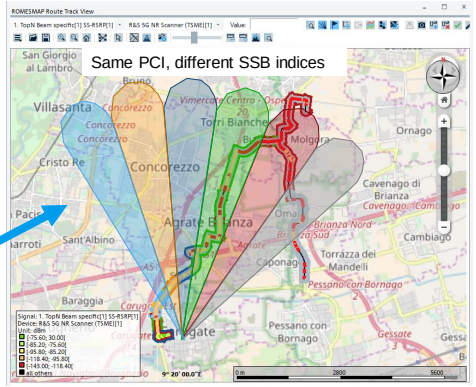
Surprisingly good coverage @ 3.75 GHz due to beamforming

-125 dBm (SS-RSRP)
Distance: ~ 6.5 km !!
In suburban environment

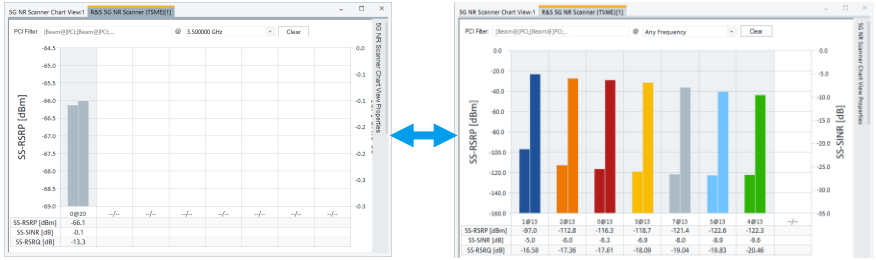


SSB Beamforming can be verified in field measurements

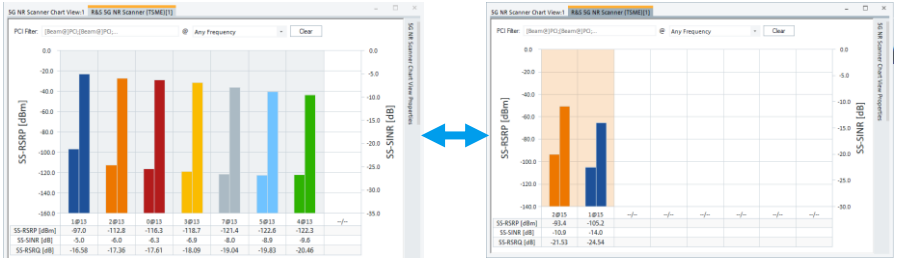
Mapping beams on SSBs is possible



5G NR SSB / beam configurations are very flexible and can be verified by field measurements



Number of received SSBs / beams depends on LOS / NLOS scenario



Conclusion

5G NR commercial mass rollout expected in 2019/2020 – pre-commercial trials now!

New technology elements drive the need for (and complexity of) 5G NR network measurements

5G NR network measurements need to cope with high flexibility and configurability

Commercial 5G NR network measurement solution available by Rohde & Schwarz

Pre-commercial trial measurements reveal surprisingly good SSB coverage due to analog SSB beamforming

➢ **Rohde & Schwarz MNT is committed to support the industry with network test solutions from early trial phase to network optimization and benchmarking**

“If you want to go fast, go alone.
If you want to go far, go together!”

African proverb

http://www.rohde-schwarz.com/MNT-5G
http://blog.mobile-network-testing.com/